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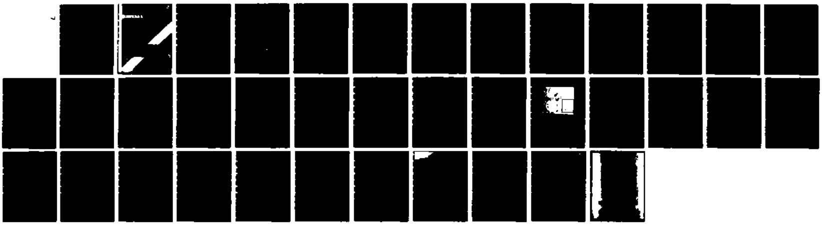

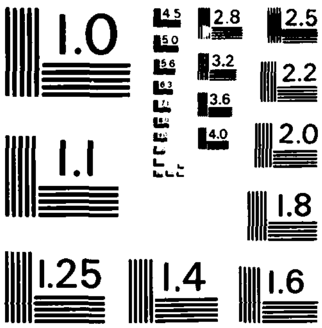

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INTERIM TEST REPORT OF EXPLOSIVE EXPANSION
INSTALLATION METHOD OF MAIN PROPULSION
BOILER TUBES

NAVSSES PROJECT B-0576

17 APRIL 1984

NAVAL SHIP SYSTEMS
ENGINEERING STATION

PHILADELPHIA, PA 19112

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by

JAMES C. MARKOS

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The explosive expansion installation test of main propulsion boiler tubes was successfully completed on 17 August 1983. Five,two inch screen tubes and five,one inch generating tubes in the DDG-15 NAVSSES test boiler were installed using the explosive expansion installation method.

Prior to expansion, tube-end protrusions were measured and recorded. After expansion, pertinent measurements were taken to verify proper tube expansion and joint integrity. After additional (and unrelated) repair work

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ABSTRACT

The explosive expansion installation test of main propulsion boiler tubes was successfully completed on 17 August 1983. Five, two inch screen tubes and five, one inch generating tubes in the DDG-15 NAVSSES test boiler were installed using the explosive expansion installation method.

Prior to expansion, tube-end protrusions were measured and recorded. After expansion, pertinent measurements were taken to verify proper tube expansion and joint integrity. After additional (and unrelated) repair work was completed on the test boiler, the boiler was hydrostatically tested. Following successful hydro, joint performance will be monitored during and after boiler operations. With successful joint performance, retubing of an active ship's boiler will be proposed using the explosive expansion method.

LIST OF FIGURES

LIST OF TABLES

ADMINISTRATIVE INFORMATION

This test was performed under the NAVSEA Manufacturing Technology Program (DNS-650). The contract number for Foster Wheeler Corp. assistance is covered by N00140-80-C-0680.

BACKGROUND:

Typical Naval boilers are equipped with 1000-1400 generating tubes. Mechanical rolling has traditionally been the method employed when expanding these tubes into boiler drums, headers, and tubesheets. In this process, a tool (expander), which consists of several expanding rolls, one or two bell rolls, and several tapered mandrels, enlarges the tube within the tube hole until contact between the two surfaces is obtained. The joint created by this process must not leak and must have sufficient pullout strength. This process requires "boilermans feel" in order to get a pressure tight seal, is time consuming and labor intensive. Frequently leaks occur after hydrostatic testing, requiring the boiler to be drained of several thousand gallons of high quality feedwater and then reopened. The joints are reworked and the process repeated. The costs are high and the elapsed time has a direct impact upon ship's availability.

A new method is presently under investigation to expand boiler tubes into drums and waterwall headers explosively. Laboratory testing at Foster Wheeler Development Corporation has been completed. The results achieved to date show this method (The Detnaform Process) to be a viable alternative to the method of mechanically rolling presently used.

ADDITIONAL INFORMATION:

The Detnaform Explosive Tube Expansion Process has been successfully used by Foster Wheeler Development Corporation for more than 15 years. The major advantages of Detnaform are:

- Unlike mechanical rolling, explosive forming does not significantly alter the grain structure of the metal. A comparison of the grain structure in rolled tubes with those explosively expanded shows the latter to be considerably less susceptible to stress corrosion.

- Explosive expansion causes the tube to conform uniformly to irregularities in the tube sheet allowing a good pressure-tight joint where this would not be possible by mechanical rolling.

- Field tube installation can be performed utilizing minimally trained technicians in comparison to the highly specialized personnel required for tube rolling.

- The Detnaform Process is repeatable. (Duplication of tube joint tightness is extremely accurate.)

- Few materials are required and they are easily transportable. Detonating cord and polyethylene inserts are the major components.

The Detnaform explosive expansion process consists of:

An explosive charge, comprised of a detonating cord encased in a polyethylene insert, is sized to fit the inside diameter of the tube within the depth of the tube sheet. The charge is inserted into the tube until a lip on the insert rests against the tube end. This lip locates the insert and prevents expansion of the tube beyond the tubesheet (see Figure 1).

The charge is detonated and the explosive force is transmitted through the insert to the tubewall. The sound and shock waves associated with the process are effectively attenuated by absorption boxes for open-faced tubesheet units and by closing the man-ways on units with elliptical or hemispherical head closures.

OBJECTIVE:

1. Demonstrate the feasibility of utilizing the explosive forming method of tube installation on a Naval boiler (DDG-15 NAVSSES Test Boiler).

2. Develop procedural and material requirements for implementing the explosive expanding method aboard Naval ships.

EQUIPMENT DESCRIPTION:

1. Charge System
   a. Polyethylene inserts
   b. Primacord explosive
      (1) 100 grains per foot
      (2) 400 grains per foot
      (3) 30 grains per foot
   c. Dupont #8 electric blasting caps
   d. Cap initiator and battery
2. Boiler Tubes
   a. 5 - 1 inch O.D. x 0.095 inch MW Generating Tubes
   b. 5 - 2 inch O.D. x 0.165 inch MW Screen Tubes
3. DDG-15 Class Test Boiler (as shown in NAVSEA Manual 0351-065-5000)
4. Safety Equipment
   a. Air horn
   b. Misfire magazine
   c. Ear plugs
   d. Warning Signs
   e. Hardhats
   f. Safety Glasses

g. Dust Particle Face Mask

h. Blasters Multi-Meter

METHOD OF TEST: (For test procedure, see Appendix I)

1. Prior to the day of the test, the following events took place:

a. Generating bank tubes RGG 1 thru 5 were removed. (See Appendix II)

b. Screen tubes RA-2, 4, 5, 6 and 10 were removed.

c. Tube seat holes were prepared for tube installation (IAW NAVSEA 0951-LP-013-8010) and hole sizes recorded.

d. Replacement tubes were procured, prepared and installed in boiler and blocked in place.

e. Preliminary safety inspections were done by NAVSSES Safety Engineer and Base Fire Department Inspector.

f. Test procedures were developed by Foster Wheeler Corp and NAVSSES and then approved by the NAVSSES Mission Readiness Panel.

2. On the day of the test, the Philadelphia Naval Base Fire Department made a final site inspection along with the Project Engineer.

3. Explosives, which were delivered to the Base Magazine earlier that day, were brought to the test site, Bldg. 633, under police and fire department escorts. Fire Department remained on site until completion of all testing.

4. Tube protrusions (projection of tube ends past inside surface of drum or header) were measured by NAVSSES and FW Corp. engineers.

5. Sharp edges or corners still remaining on tube ends were filed by boilermaker.

6. F-W blaster performed safety checks with blasters multi-meter.

7. The following charge systems were prepared:

Tube Size		Primacord Size	Primacord Length(2)	Location(3)
1"	N/A	100 grains/ft	5-1/8"	Steam Drum
1"	N/A	100 grains/ft	2-7/8"	Water Drum
2"(1)		400 grains/ft	5-5/16"	Steam Drum
2"(1)		400 grains/ft	2-3/16"	Water Drum

NOTES:

(1) In addition, the 2" tubes had an additional wrap of 4-1/4" of 100 grains/ft for tube end belling (flare).

(2) Above Primacord length is for joint expansion. An additional 1-1/2" was present for attachment of blasting cap.

(3) After the first 3 blasts, an 8" tail of 30 grains/ft primacord was added to locate blasting cap away from tube end.

8. After additional safety checks by blaster and area checks for personnel, a charge was inserted into one inch tube RGG-5 in the water drum and the first blast was made. The bell (flare) was checked and found to be in spec.

9. After the 2nd blast on RGG-4 in water drum, a notch or ding was noted at the 7 o'clock position of tube.

10. For fourth blast on RGG-2 in water drum, an 8" tail of 30 grain/ft primacord was attached to locate the blasting cap away from the tube end and prevent possibility of the cap's metal shell from damaging the tube end as on tube RGG-4. All remaining blasts were done with a tail (of approximately 8" of 30 grain/ft.)

11. After the fifth blast on RGG-1 in water drum, the five bells (flares) were measured and recorded (See Table IV).

12. Prior to expanding the upper, steam drum ends of the one inch tubes, tube protrusion was checked again. All tubes had shifted slightly, caused by the initial blasts and had to be reset prior to each blast in the steam drum. (This proved to be very time consuming.)

13. Five,one inch tubes were explosively expanded in the steam drum after checking each protrusion.

14. Two-inch tubes in the steam drum were the next to be explosively expanded. Tube end protrusion was checked prior to each expansion and did not require readjustment. The drum door was partially closed prior to each blast to muffle the noise of the blast.

15. After expansion of all two inch tubes, flares were measured and recorded.

16. The protrusion of the two inch tubes in the screen header were not measured again (prior to expansion) since the upper ends had little or no variation between initial and final checks.

17. For the fifth expansion in the screen header, on tube RA-2, a flat was shaved on the polyethylene insert to allow it to pass into the tube which had a flat spot on it.

18. After the last expansion, the extra blasting caps and primacord was disposed of. (See deviation listing of Appendix I for disposal method.)

DISCUSSION

A. Tube Joint Evaluation Criteria

In accordance with NAVSEA S9086-GY-STM-000/CH-221 (Chapter 221) and NAVSEA 0951-LP-031-8010 (8010), the basic tube joint in a boiler must fulfill two requirements:

1. It must not leak
2. It must not be deficient in holding strength.

B. Leakage

After the boiler had been waterjetted and passed inspection, the boiler was hydrostatically tested. Although a 125% hydro is normally required for initial

testing of tube replacements, a 150% hydro is required as a result of other unrelated repairs recently completed on the boiler. Paragraph 221-2.338A (pg 69) of Chapter 221 and paragraph 1.9.1.2-6 of 8010 give the criteria for defining a leaking joint and the corrective measures necessary to correct a leaking joint. If the joint leaks, it can be hand re-rolled and retested (with a 100% hydro).

During the initial hydro, all explosively expanded tubes held pressure. However, tubes adjacent to the explosively installed tubes were found to leak (See Appendix II). Generating tubes RFF-1, 2, 3 and 5 leaked at each end and screen tubes RB-3, 5, 6, 7 and 11 leaked at each end. One other unrelated sidewall tube also had a minor leak. The tubes that leaked were all mechanically rerolled and successfully hydrostatically tested to 125% of operating pressure. Except for the unrelated side wall tube, it is evident that the explosive expansions had an effect upon the tubes that leaked. This problem will be studied prior to additional testing and may indicate that the explosive method is acceptable for entire retubing only and not suitable for individual replacements.

C. Expansion of Tubes

The holding strength of a joint must be sufficient to prevent the tube from pulling out of its seat. Proper expansion (along with belling) of a tube into the tube seat will give sufficient strength. Proper expansion of the two-inch tubes can be determined by the formula given in Chapter 221 (paragraphs 221-2.298 thru 2.301) and in 8010 (paragraph 1.6.1). The formula for determining proper expansion of the two-inch tubes and results from the explosive installation are shown in Table I. The Minimum Dimension column gives the Inside Diameter (I.D.) target dimension and the Actual Dimension column gives the I.D. of the tubes after expansion.

As can be seen from Table I, the actual dimensions (ID) exceeded the minimum dimensions (ID) in all but three joints and the variation in those three joints (from minimum) was 0.0128 inch or less. The actual dimensions (ID) varied less than 0.0178 inch for the two inch tubes in the steam drum and less than 0.006 inch among those in the screen header. The "repeatability" and consistency of these dimensions are excellent.

After expanding one inch tube RGG-4 in the water drum, a "Vee" notch or split was found at the belled end of the tube (see Figure 2). A tool mark, or tube defect, may have caused this. It is also possible that the metal case of the blasting cap may have caused the problem. To eliminate this possibility, tails of 30 grain per foot primacord were added after the third blast as indicated in the deviation listing in Appendix I. The tail, which does not effect the expansion process allowed the blasting cap to be placed approximately six inches away from the tube end. No "Vee" notches or splits were found on the tube ends after this change. A visual inspection of RGG-4 was made to determine if the tube had a crack or tool mark prior to expansion. No tool mark was found but a discoloration on the tube end in the area of the "Vee" may be indicative of a minor flaw or defect in the tube. It is also possible that the tube split was caused by inadequate "rounding" of the tube end prior to expansion. The ends are rounded prior to expansion to prevent splitting during belling when mechanically rolling. The degree of "rounding" of the tubes in this test were less than would be required for mechanically rolled tubes.

The metal shell of the blasting cap would not be a problem during expansion on a production basis, since only one cap would be used to initiate several expansion charges at one time, with all of the charges linked together by tails.

The Percent Reduction of Tube Wall Thickness Method can be used to determine if adequate expansion has been made for both the one inch and two inch tubes. The tube wall thickness after expansion as compared to the tube wall thickness of the unexpanded tube, expressed as the percent reduction of the original unexpanded tubewall thickness, is indicative of the degree of expansion that has occurred. For the two inch tubes, the formula used in Table I for determining the target dimension can also be used to determine the targeted Percent Wall Reduction. The targeted value is listed in Table II. This value indicates a wall reduction of 10.46 percent (as calculated with the formula and data from Table I) will ensure an adequate joint. For the one inch tubes, the percent wall reduction is listed in Table II. There is no applicable formula to determine a targeted wall reduction value for these tubes; however, a tube with a smaller wall thickness would generally require less reduction in wall thickness for adequate strength. The actual reduction in wall thickness of the one inch tube is shown in Table III.

D. Tube Belling

Proper belling (along with expansion) is necessary to ensure adequate pull-out strength of the tube joint. Table IV gives the bell sizes after expansion. Expansion and belling are done simultaneously in a single blast. As can be seen from the table, the belling dimensions of either tube size at either end varied only slightly. For the one inch tubes in the water drum, the bell varied only 0.017 inch between the largest bell (tube RGG-4) and the smallest bell (tube RGG-1). For the one inch tubes in the steam drum, the bell varied only 0.0085 inch between the largest and smallest bells and with tubes RGG-2 and 3 being slightly below the minimum specification.

For the two inch tubes in the screen header, the bell varied 0.056 inch between the largest and smallest bells, tubes RA-5 and RA-2, respectively. Although tubes RA-5, 6 and 10 have bells slightly larger than the maximum specification, their dimensions are close to the bells of the three rolled tubes taken for comparison. It should also be noted that difficulties in measuring the screen tube flares in the screen header due to limited access may have adversely affected these measurements. For the two inch tubes in the steam drum, the bells varied only 0.034 inch between the largest and smallest bells. The overall uniformity of the tube belling dimensions are excellent.

E. Procedures and Methods to be Developed

A procedure must be developed to secure the tubes in place prior to expansion to use this new method on a production basis. During this test, the one inch generating tubes had shifted (the protrusion changed) in the steam drum after explosive expansion had been accomplished on these tubes in the water drum. Prior to each expansion of the one inch tubes in the steam drum, each tube protrusion had to be reset. This would be entirely unfeasible on a production basis. This problem will be addressed prior to the final test installation during a ship's overhaul.

The final concern for the production use of this method is the safe use of explosives. This test used one cap for each explosive charge per tube end. In actual production use, one cap will be used for several tube expansions at a time. This will limit the number of caps needed. However, the caps can be detonated by stray currents and radio transmissions. One way to avoid this problem would be to explosively form tubes during an "off" shift or on a weekend with no one other than the blasting crew aboard and the ship completely shut down (de-energized). The blast crew will have to be properly trained, licensed and supervised. This problem will be addressed in preparation of the final installation test on a ship's boiler.

CONCLUSIONS

Based upon measurements, calculations and results of hydrostatic testing, the following can be concluded:

1. The explosive expansion tube installation method can properly expand a boiler tube in a Naval Boiler. However, additional testing will be necessary to determine if the explosive expansion method is a viable alternative to the mechanical rolling method.

2. Calculations done in accordance with NAVSEA Chapter 221, for two inch tubes, indicates that the five,two inch tubes explosively expanded in this test have been adequately expanded. Visual inspection shows a remarkably smooth and even "coining" of the tube wall into the tube seat serrations.

3. Additional testing will be necessary to determine if partial retubing can be done by the explosive expansion method without affecting presently installed tubes which occurred during this test.

4. Calculations done in accordance with the Percent Wall Reduction Method indicate that both the one inch and two inch tubes have been adequately expanded.

RECOMMENDATIONS

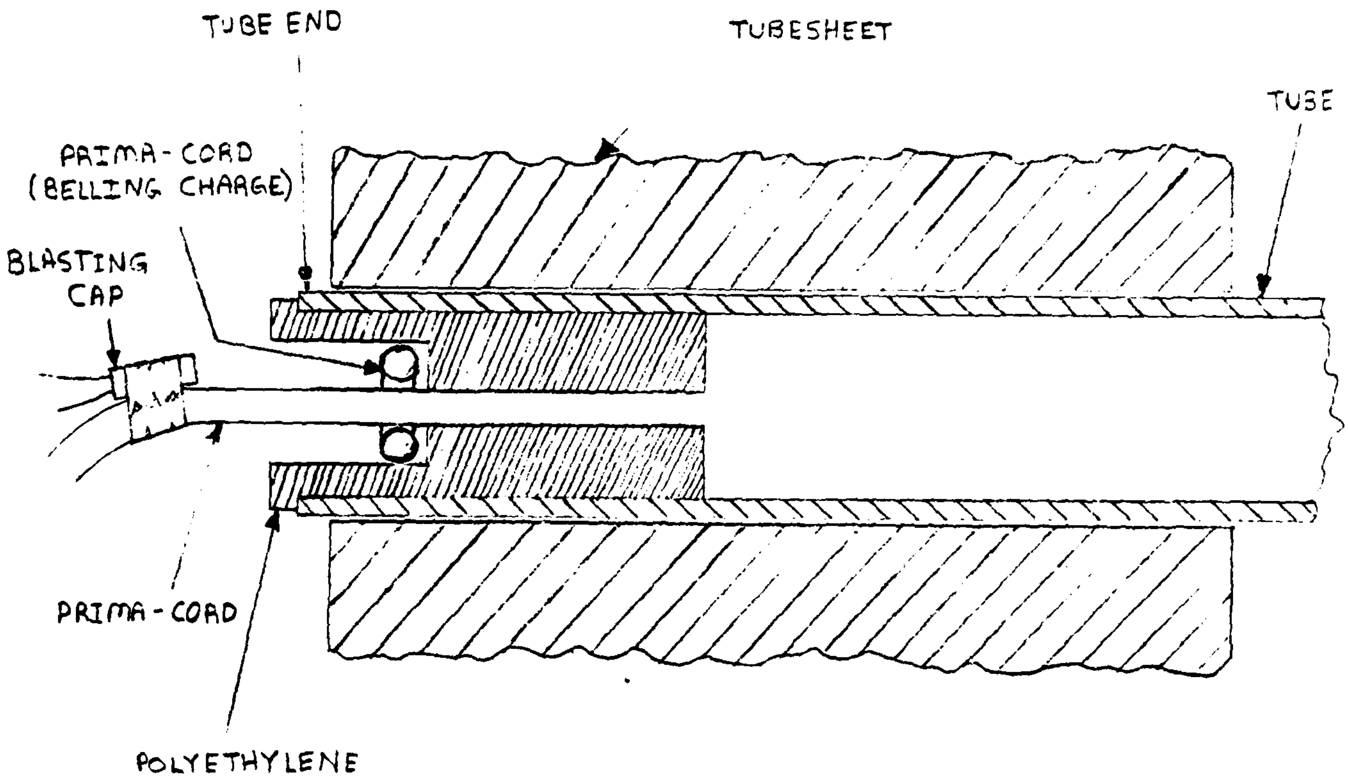
1. Conclude testing by operating test boiler and monitoring joint performance after the boiler has been water-jetted and inspected.

2. Additional study must be done to determine the effect the explosive expansion method has on presently (previously) installed tubes.

3. Upon conclusion of testing, begin the third and final phase of the Explosive Forming Installation Test by retubing a main boiler aboard a Naval vessel and monitoring tube joint integrity.

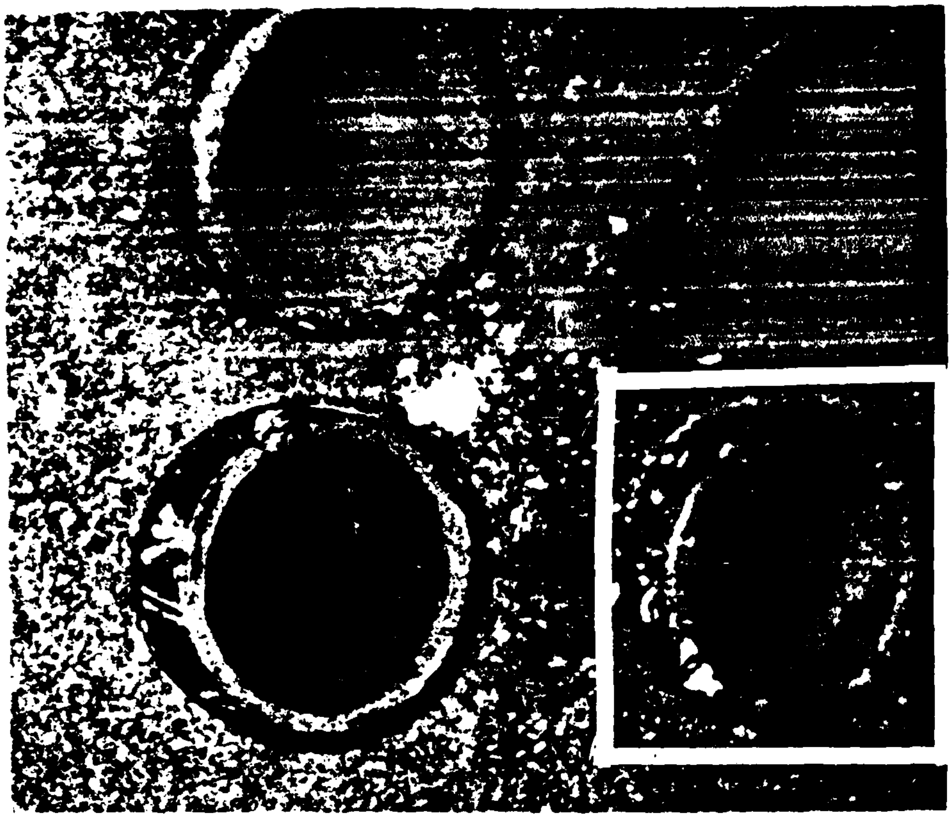
4. Upon successful conclusion of all testing, develop an approved procedure for tube installation using the explosive forming method. This procedure would cover major retubing, as well as individual tube replacements, for all tubes up to and including two inches OD, with the exception of superheater tubes, on 600 PSI and 1200 PSI main boilers.

5. Funding be provided to develop methods and procedures for Explosive Installation of Superheater Tubes on 600 PSI and 1200 PSI main boilers.



EXPLOSIVE INSERT POSITIONED IN A TUBE
AND TUBE SHEET ASSEMBLY

FIGURE 1



One-Inch Generating Tube RGG-4 in Water Drum

Note "Vee" notch at 7 O'clock position.

Figure 2

Tube Expansion Data for Two Inch Screen Tubes

Tubes - 2" O.D. x 0.165" MW with 0.1865" Average Wall Used in calculations

Drum	(ID of Tube)	+	(Tube hole dia)	-	(OD of tube)	+	(Expansion Factor) 1		Inside Diameters Minimum Dimension	Inside Diameters Actual Dimen.
RA-2	1.6325	+	2.014	-	2.0055	+	0.039	=	1.68	1.6735
RA-4	1.6355	+	2.015	-	2.0085	+	0.039	=	1.681	1.6682
RA-5	1.637	+	2.017	-	2.01	+	0.039	=	1.683	1.674
RA-6	1.6385	+	2.016	-	2.0115	+	0.039	=	1.682	1.6855
RA-10	1.6305	+	2.015	-	2.0035	+	0.039	=	1.681	1.686
Header										
RA-2	1.6325	+	2.03	-	2.0055	+	0.039	=	1.696	1.714
RA-4	1.6355	+	2.031	-	2.0085	+	0.039	=	1.697	1.71
RA-5	1.6385	+	2.03	-	2.01	+	0.039	=	1.696	1.715
RA-6	1.6385	+	2.031	-	2.0115	+	0.039	=	1.697	1.71
RA-10	1.6305	+	2.032	-	2.0035	+	0.039	=	1.698	1.709

1. Expansion Factor from NAVSEA 0951-LP-031-8010, Page 1-52, Figure 1-24

TABLE I

Tube Expansion Data for Two Inch Tubes Based on Percent Wall Reduction

Drum	[(Tube Hole Dia. Before Exp.)	-	(Tube I.D. After Exp.)]	÷2=	Expanded Tube Wall Thickness	Percent Reduction of Tube Wall Thickness Actual[1]	Target[2]
RA-2	(2.014)	-	(1.6735)	=	0.17025	8.71	10.46
RA-4	(2.015)	-	(1.6682)	=	0.1734	7.02	10.46
RA-5	(2.017)	-	(1.674)	=	0.1715	8.04	10.46
RA-6	(2.016)	-	(1.6855)	=	0.16525	11.39	10.46
RA-10	(2.015)	-	(1.686)	=	0.1645	11.8	10.46
Header							
RA-2	(2.030)	-	(1.714)	=	0.158	15.3	10.46
RA-4	(2.031)	-	(1.71)	=	0.1605	13.94	10.46
RA-5	(2.030)	-	(1.715)	=	0.1575	15.55	10.46
RA-6	(2.031)	-	(1.71)	=	0.1605	13.94	10.46
RA-10	(2.032)	-	(1.709)	=	0.1615	13.40	10.46

1. Actual Percent Reduction = $100 - (\text{EWT})\left(\frac{100}{\text{Avg. Wall Thickness}}\right)$
   Average tube wall thickness before expansion = 0.1865 inch

2. As specified in NSTM Chapter 221

TABLE II

Tube Expansion Data for One Inch Tubes Based on Percent Wall Reduction

	[(Tube Hole Dia. Before Exp.)	-	(Tube I.D. After Exp.)] ÷2	=	Expanded Tube Wall Thickness	Percent Reduction of Tube Wall Thickness Actual [1,2]
Steam Drum						
RGG-1	1.014	-	0.8158	=	0.0991	9.91
RGG-2	1.011	-	0.8155	=	0.09775	11.14
RGG-3	1.012	-	0.8127	=	0.09965	9.41
RGG-4	1.017	-	0.8130	=	0.1020	7.3
RGG-5	1.016	-	0.8095	=	0.10325	6.4
Water Drum						
RGG-1	1.009	-	0.8080	=	0.1005	8.64
RGG-2	1.010	-	0.8078	=	0.1011	8.09
RGG-3	1.010	-	0.8108	=	0.0996	9.45
RGG-4	1.009	-	0.8123	=	0.09835	10.59
RGG-5	1.010	-	0.8080	=	0.101	8.18

1. Actual Percent Reduction = 100 - (Expanded Tube Wall Thickness) $\left(\frac{100}{\text{Avg. Tube Wall Thickness}} \right)$

   Avg. tube wall thickness before expansion = 0.110 inch

2. No target specified in NSTM 221

TABLE III

TUBE BELL DATA

One inch tubes	Water Drum		Steam Drum
RGG-1	1.0740	Average of two	1.0715
RGG-2	1.0765	measurements	1.0660
RGG-3	1.0780	taken 90° apart	1.0635
RGG-4	1.0910		1.063

Spec for 1" tube - 0.0625" to 0.125" plus tube OD

Two inch tubes	Screen Header*		Steam Drum
RA-2	2.184		2.1510
RA-4	2.189	Average of two	2.1650
RA-5	2.240	readings taken	2.1850
RA-6	2.229	90° apart	2.1830
RA-10	2.214		2.1830

Spec for 2" tube - 0.125" to 0.188" plus tube OD

*Bells of three rolled tubes in screen header, measured for comparison:

A) 2.215"

B) 2.209"

C) 2.298"

TABLE IV

EXPLOSIVE EXPANSION INSTALLATION METHOD OF

MAIN PROPULSION BOILER TUBE

TEST PROCEDURE

Project Engineer Jim Markos

02 [illegible] 8/5/83

022 [illegible] 8/8/83

022D [illegible] 8/3/83

EXPLOSIVE EXPANSION TEST PROCEDURE

1.) Scope

This procedure covers the method for conducting the kinetic expansion of tubes into drums and headers on a Navy test boiler, Type DDG-15. The cleaning of the tube ends and tube holes, and the installation and alignment of the tubes prior to expansion has been completed by personnel of the NAVSSES shop in accordance with NAVSEA S9086-GY-STM-000 Chapter 221 and NAVSEA 0951-LP-031-8010 and is outside the scope of this test.

2.0 Equipment

The equipment needed to perform the expansions includes:

2.1 Charge System

1. Polyethylene insert
2. Explosive

2.2 Electric blasting caps

1. Dupont #8

2.3 Extension Lead Cord

2.4 Cap initiator

1. Battery

2.5 Siren or whistle

Foster Wheeler Development Corporation (FWDC) will provide the necessary equipment.

3.0 Procedure for Kinetic Expansion

Once the tubes have been installed in-place and are ready to be kinetically expanded, the following procedure will be used:

3.1 The immediate vicinity of the blast site will be cordoned off to prevent unwanted personnel from wandering through.

3.2 The charge system will be slid into the tube until the collar of the insert bottoms against the end of the tube. Tape may be used to hold the insert in-place if it tends to slip out.

3.3 An electric blasting cap will be taped to the end of the explosive charge.

3.4 The lead wires of the blasting cap will be connected to the wires at one end of the extension lead cord. The other end of the lead cord will be positioned a safe distance from the blast site.

3.5 A siren or whistle will be sounded to warn personnel of the impending blast.

3.6 The cap will be detonated by placing the wires of the extension lead cord across the terminals of a battery. The energy from the exploding cap will initiate the explosive charge.

3.7 After successful detonation, the spent insert will be removed from the tube.

3.8 Steps 3.2 through 3.7 will be repeated for the other tubes.

4.0 Safety Precautions

The following safety precautions should be maintained during the kinetic expansion of tubes into drums and headers on the test boiler:

1. The work area shall be identified as a blast site and shall be roped off to prevent unwanted personnel from wandering through.

2. No smoking, no open flames and no hot work shall be permitted during the blasting operations.

3. The immediate area shall be checked for stray currents with a blaster's multimeter.

4. NAVSSES employees shall wear safety glasses or face shields and noise attenuators; i.e., ear muffs or ear plugs. Hard hats shall be worn on the Test Site.

5. The Project Engineer shall be in charge of the Test Project. Contractor personnel shall comply with the Safety Precautions.

6. Word shall be passed or a whistle shall be sounded prior to the blast.

7. Procedures to be followed in the event of a blasting cap misfire. Clear the Test Site for at least 15 minutes. Then the licensed blaster (contract employee) may proceed with established safety checks.

8. Procedures to be followed in the event of incomplete burning of the prima-cord. Clear the test site for at least 15 minutes. Then the licensed blaster may proceed with established safety checks.

9. The test procedure shall be performed after regular work hours in order to reduce potential exposure of employees.

Should the blasting cap fail to detonate on cue, the following procedure to handle the misfire will be used:

10.1 Remove the firing line from blasting machine and recheck firing circuit continuity. If continuity is good proceed to step 10.3.

10.2 If firing line continuity is bad, repair or replace cable. Recheck continuity.

10.3 Check blasting machine for proper operation. If faulty or questionable, replace with another machine. If the machine is in proper working order, proceed to step 10.4.

10.4 Wait 15 minutes, then licensed blaster approaches the detonator and checks the connection to the firing line. If probable misfire cause is found, make necessary repairs to connection.

10.5 If detonator still does not fire, blaster shall disconnect the detonator from the firing line and re-shunt the detonator lead wires by twisting them securely together.

10.6 The blaster shall then carefully remove the detonator from the insert and store in misfire magazine.

10.7 Obtain a new detonator and proceed with Kinetic Expansion procedure.

10.8 The blaster will destroy the faulty detonator at the end of the shift or alternate time by placing in contact with another detonator and cause it to fire by sympathetic detonation.

10.9 Licensed blaster will complete blast record for misfire disposal detonations.

NOTE: Authorization to conduct this test has been granted by the Commander, Naval Base, Philadelphia, PA and is attached as enclosure (1).

References (a) and (b) of enclosure (1) are addressed in enclosure (2).

Enclosure (3) amends dates in enclosure (1).

DEPARTMENT OF THE NAVY
COMMANDER, NAVAL BASE
PHILADELPHIA, PENNSYLVANIA 19112

NAVSSES PROJECT B-0576

IN REPLY REFER TO
N46(MLS):afd
5450/#248

-8 JUL 1983

From: Commander, Naval Base
To: Commanding Officer, Naval Ship Systems Engineering Station, Philadelphia, Pa. 19112

Subj: Boiler Tube Explosive Expansion Test

Ref: (a) Phoncon 5 Jul 83 NAVSTA (CDR Senft)/NAVSSES (Mr. Markos)
(b) NAVSEA OP 5 Ammunition and Explosives Ashore
(c) COMNAVBASEPHILAINST 5450.4F

Encl: (1) NAVSSES Plan of Action for Boiler Tube Explosive Expansion Test
(2) Foster Wheeler Development Corporation Ltr of 31 Jan 83

1. As discussed during reference (a), authorization is granted for conduct of Boiler Tube Explosive Expansion Test during period 26-28 July 1983 utilizing blasting caps (quantity 30) and Primacord (½ pound) as outlined in enclosures (1) and (2). Safety precautions shall be in accordance with references (b) and (c).

2. Request provide advance notification to the NAVBASE Ordnance Officer, Fire Department and Police Department and NAVSTA Code 5 regarding the exact time of receipt or movement to/from storage for explosives in order to permit arrangements for escort and protection services. Explosive materials will be stored in Philadelphia Naval Station Magazines (Bldgs 1Y1 and 1Y3) until the time of test and between testing events as required. Request provide via letter to the Naval Station Code 5 the names of personnel authorized to pickup material from storage.

3. Points of Contact:

NAVBASE Ordnance Officer	Cdr Senft X3716
NAVBASE Fire Department	X3329
NAVBASE Police Department	Watch Commander Desk X3740/2025
NAVSTA Code 5	GMG1 Nussman X3910

M. L. Senft

M. L. SENFT
By direction

Copy to:
COMNAVBASE Phila 01,N3
COMNAVBASE Phila Police Dept
COMNAVBASE Phila Fire Dept
NAVSTA Phila Code 5

Appendix (I)
Enclosure (1)

NAVSSES PROJECT B-0576

011.1:JWC:os
5100
Ser 178

21 JUL 1983

MEMORANDUM

From: 011.1
To: 022D
Via: 011 Rm 7/22-forded

Subj: Boiler Tube Explosive Expansion Test, Safety Precautions

Ref: (a) NAVSEA OP5 Ammunition and Explosives Ashore

(b) COMNAVBASEPHILAINST 5450.4F

1. Safety precautions, concerning the possession, use and storage of the explosives to be used in subject test, will be in compliance with the requirements contained in references (a) and (b).

Joseph W. Counts
Joseph W. Counts
Safety Manager

Copy to:
01, 02, 022

Appendix (I)
Enclosure (2)

NAVSSES PROJECT B-0576

022D:JM:smc
9221 (B-4449)
Ser 533
3 August 1983

RECORD OF TELEPHONE CONVERSATION

PROJECT NO.: B-4449 DATE: 2 August 1983 TIME: 0850

CONVERSATION INITIATED BY: James Markos (NAVSSES -022D)

WITH: CDR Senft, NAVBASE Ordnance Officer (755-3716)

PURPOSE: To change authorization date for conducting boiler tube explosive expansion test

REFERENCE: (A)

LTR:N46(MLS) Ser 5450/H248 from COMNAVBASE Philadelphia to NAVSSES

RESUME OF POINTS DISCUSSED AND CONCLUSIONS REACHED:

Reference A, granted authorization to conduct boiler tube expansion test during 26-28 Jul 83. This phone call requested authorization to conduct test during August, between 8/17 to 8/24. CDR Senft gave authorization for testing during 8/17 to 8/24 by this phone conversation, and requires another call confirming actual date, prior to testing. Final authorization (which will ammend reference A) will be by record of phone conversation.

Jim Markos

James Markos
Amphibious Warfare Ship Boiler Section

Appendix (I)
Enclosure (3)

Commonwealth of Pennsylvania
Department of Environmental Resources
Division of Explosives

BLASTER'S LICENSE

Expires
August 31, 1983

KIM D. GABRIEL
256 WATCHUNG AVENUE
GLEN RIDGE, NJ
07028 4994-C

Kim D. Gabriel
Signature

ER-QE-27: Rev. 4/82

EXPLOSIVE EXPANSION INSTALLATION METHOD OF
MAIN PROPULSION BOILER TUBE - TEST PROCEDURE

A REVIEW OF THIS PROCEDURE HAS BEEN COMPLETED AND IS TECHNICALLY CORRECT WITH THE EXCEPTION OF DEVIATIONS LISTED BELOW. DO NOT REMOVE THIS PAGE.

DEVIATION LISTING

The following deviations to the test procedure were made during testing.

To, step 3.3., after the 3rd blast, a primacord "tail" was attached to the main change. The blasting cap was then attached to the tail. This moved the cap away from the tube end to prevent possible damage to tube end from metal shell of cap.

To, step 3.7. A few inserts were "lost" in tubes or header. Service request was forwarded to shop to blow-out tubes and clear out debris.

Also, after testing excess was disposed of as follows:

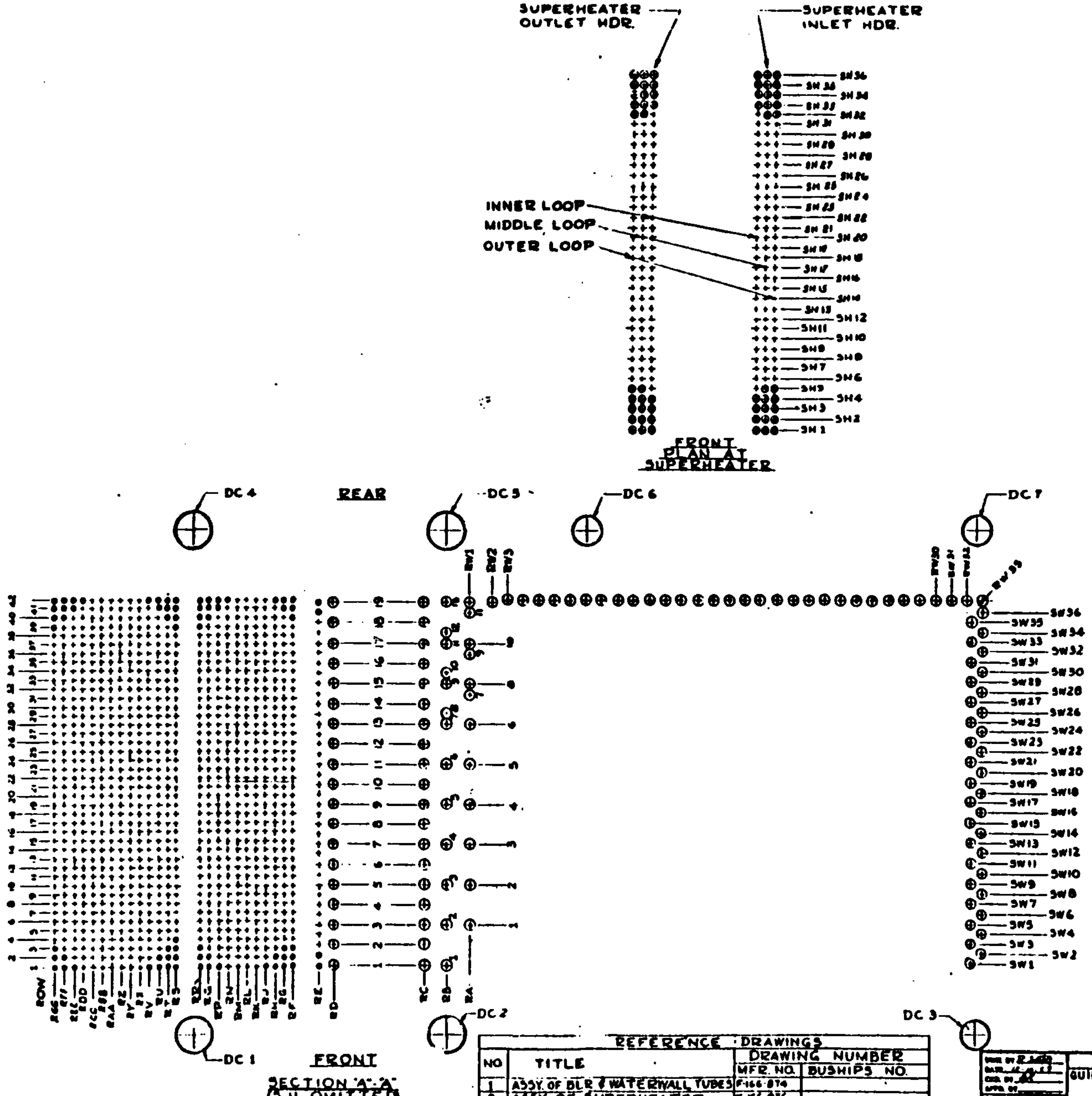
1. Five extra caps were detonated in blast cylinder placed in water drum (1 blast w/2 caps and 1 blast with 3 caps).

2. Excess primacord was burned by blaster under supervision of Base Fire Dept. at Base airfield.

PROJECT ENGINEER [signature]

DATE 8/23/83.

28



NOTES

1. WHEN REFERRING TO TUBES IN CORRESPONDENCE OR REPORTS, IDENTIFY TUBES AS FOLLOWS:
GENERATING TUBES-GIVE LETTER OF ROW AND NUMBER OF TUBE, COUNTING FROM FRONT TO REAR OF BOILER.
SUPERHEATER TUBES-GIVE THE LOOP & NUMBER OF TUBE, COUNTING FROM FRONT TO REAR
ECONOMIZER TUBES-GIVE LETTERS & NUMBER OF THE TUBE AS INDICATED IN CROSS SECTION OF THE ECONOMIZER.
DOWNCOMER TUBES-GIVE NUMBER OF TUBE.
REAR WALL TUBES-GIVE NUMBER OF TUBE, COUNTING FROM LEFT TO RIGHT.
SIDE WALL TUBES-GIVE NUMBER OF TUBE, COUNTING FROM FRONT TO REAR.

REFERENCE DRAWINGS

NO	TITLE	DRAWING NUMBER MFR. NO.	DRAWING NUMBER BUSHIPS NO.
1	ASSY. OF BLR & WATERWALL TUBES	F-166-874	
2	ASSY. OF SUPERHEATER	F-166-876	
3	ASSY. OF ECONOMIZER	F-166-877	
4	ASSY & DET. OF DOWNCOMERS	F-166-875	

GUIDED MISSILE DESTROYERS
DDG 15-19 CLASS
MAIN BOILERS
TUBE IDENTIFICATION

COMBUSTION ENGINEERING INC.
NEW YORK, N.Y.
F-166-941-C

END

FILMED

7-84

DTIC